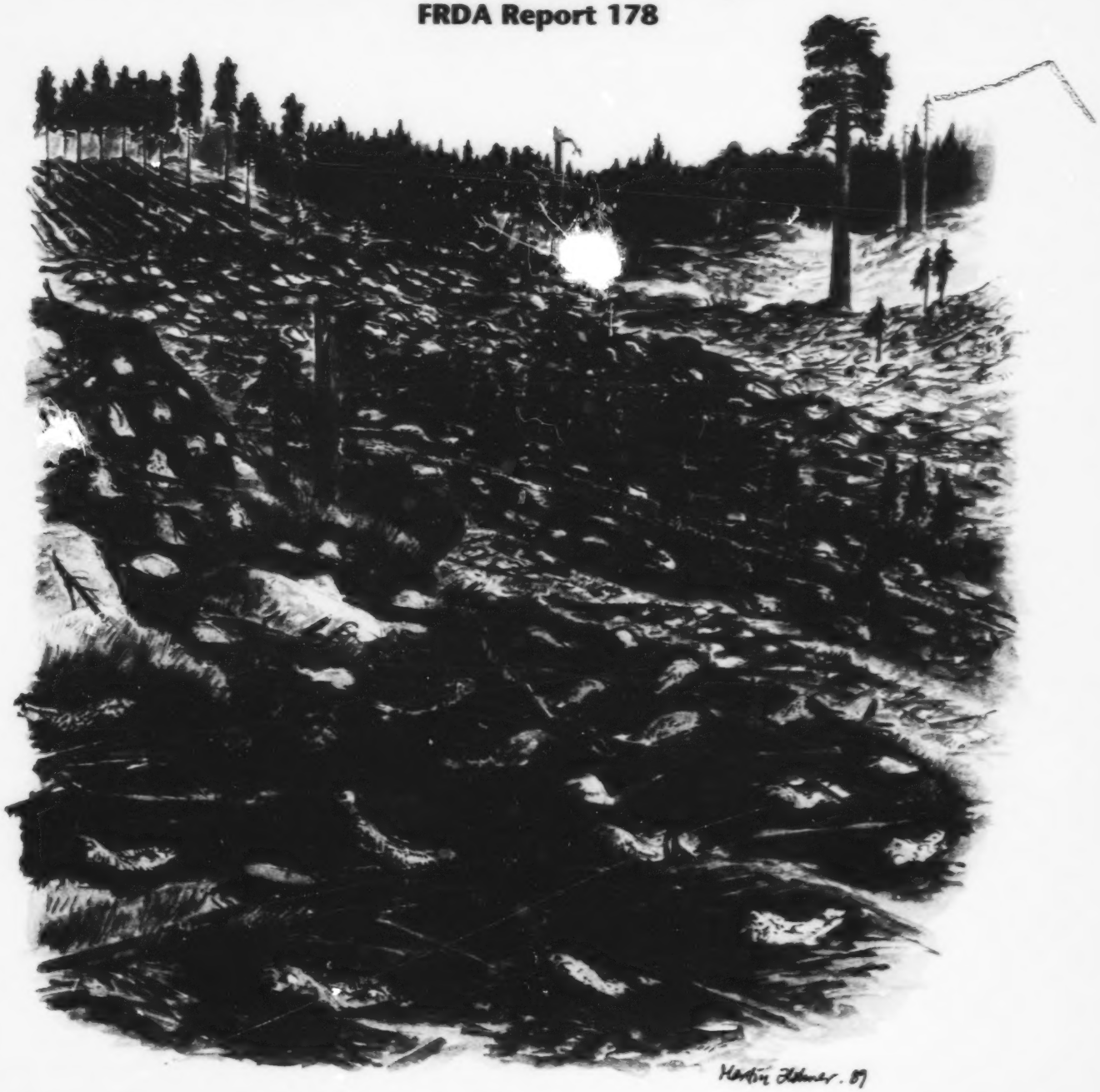
Fundamentals of Mechanical Site Preparation

FRDA Report 178



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Marc A. von der Gönna

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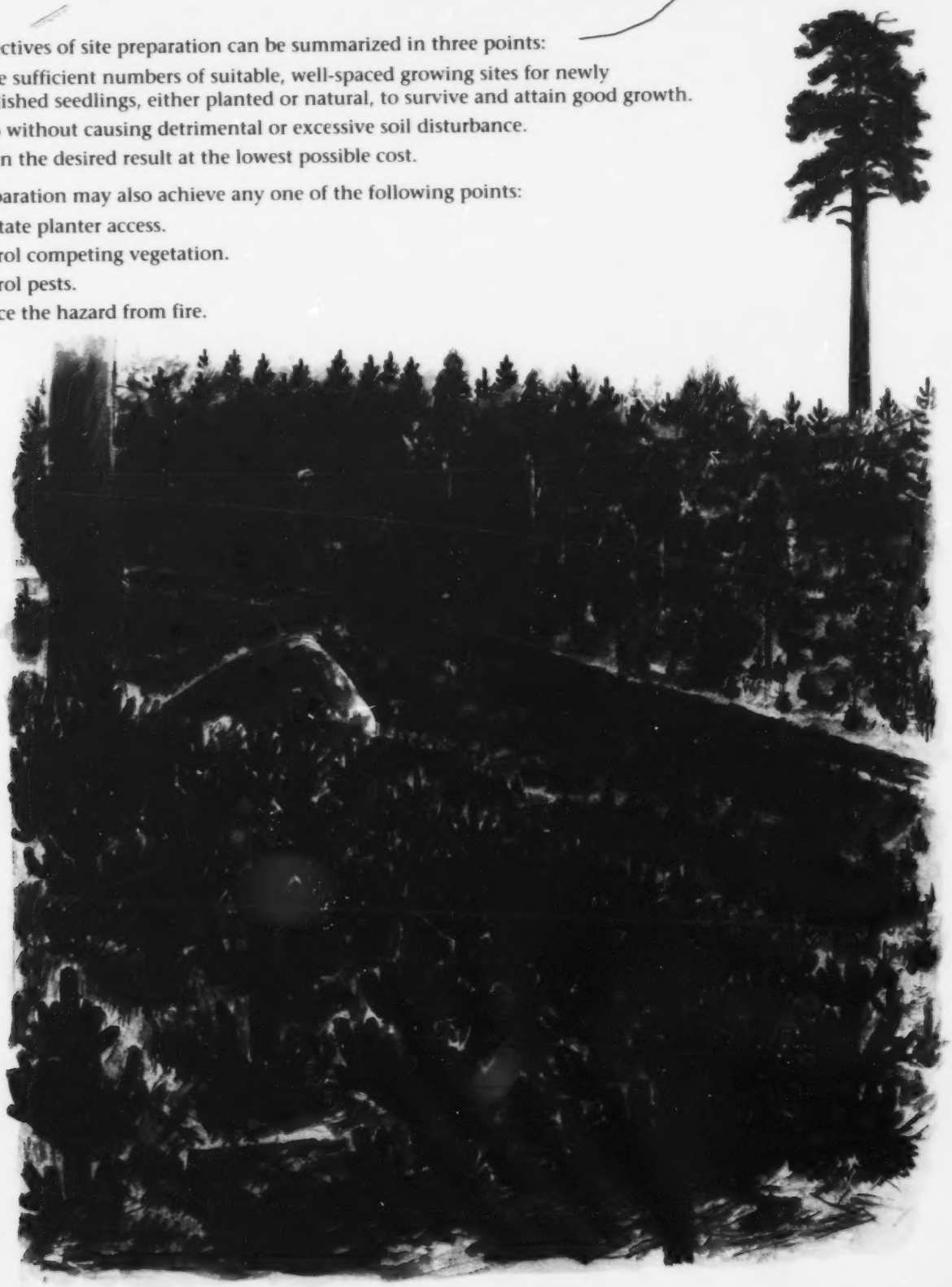
OBJECTIVES

The objectives of site preparation can be summarized in three points:

- Create sufficient numbers of suitable, well-spaced growing sites for newly established seedlings, either planted or natural, to survive and attain good growth.
- Do so without causing detrimental or excessive soil disturbance.
- Obtain the desired result at the lowest possible cost.

Site preparation may also achieve any one of the following points:

- Facilitate planter access.
- Control competing vegetation.
- Control pests.
- Reduce the hazard from fire.



WHAT IS SITE PREPARATION?

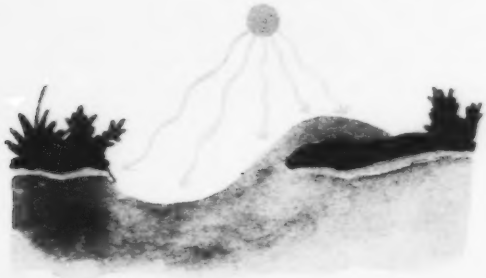
Site preparation creates a favourable growing area for seedlings and good germination spots for seeds. This is accomplished by physically altering slash, duff, and soil layers by a variety of methods, including scalping, trenching, plowing, mixing and mounding. Through site preparation, factors that are limiting for seedling survival and growth may be overcome.

Correctly performed site preparation creates enough disturbance to overcome limiting site factors without causing excessive soil disturbance or degradation. Combined with natural seeding or proper planting techniques, site preparation can give seedlings a good start. This is shown by evidence of the following results:

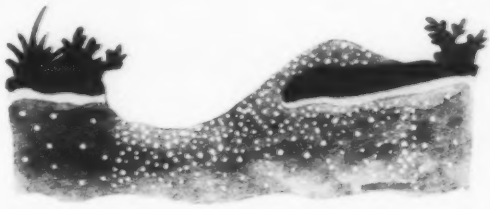
- Quick development of the root system (good establishment).
- High survival.
- Good growth.

WHAT CAN BE ACCOMPLISHED THROUGH SITE PREPARATION?

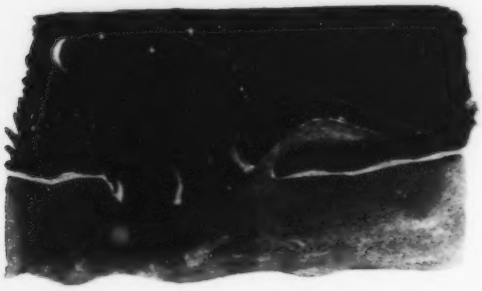
Through proper, ecosystem-based prescription, site preparation can overcome many unfavourable site factors. However, when applied incorrectly or on the wrong site or ecosystem, site preparation can also create unfavourable growing conditions.



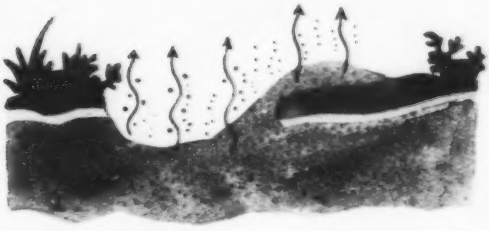
The temperature in the root zone can be increased.



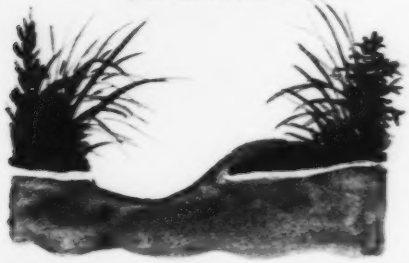
Available oxygen in the soil can be increased.



The risk of frost damage can be decreased (in some cases).

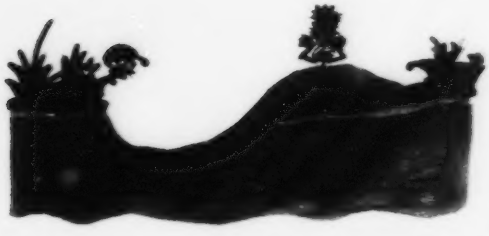


Moisture problems, such as drying out or waterlogging, can be overcome.



Competing vegetation can be reduced.

Nutrient availability can be increased.



The risk of insect attack can be reduced.

Planting can be made easier.

SITE PREPARATION METHODS

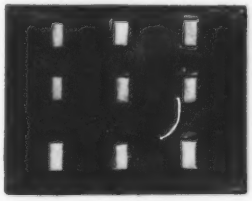
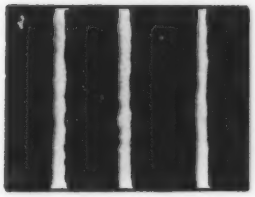
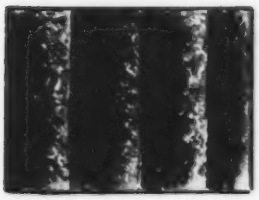
This guidebook deals with five mechanical site preparation methods commonly used in British Columbia—scalping, trenching, plowing, mixing and mounding. Drag scarification for natural regeneration and slash treatments, such as piling or windrowing, is not covered.*

Soil Disturbance

Mechanical site preparation can be defined as planned soil disturbance to achieve desired silvicultural objectives. Excessive soil disturbance, however, can lead to unwanted results such as removal of nutrients beyond seedling root systems, compaction, erosion, or even landslides. On the other hand, too little disturbance may not be sufficient to achieve the desired objectives, such as controlling competing vegetation. In general, the following quotation should be used as a working guideline:

"as much as necessary but as little as possible".

Different site preparation methods create different amounts and types of soil disturbance. When selecting the site preparation method, one must consider the sensitivity of the site to long-term degradation.

Method	Area of ground surface disturbed
Spot scarification and mounding.	 10–30 %
Disc trenching	 25–50 %
Plowing	30–65 %
Mixing (e.g., bedding plow, Madge)	 up to 100 %

* For information regarding these treatments see: *Drag scarification in British Columbia* and *Guide for windrowing logging slash in the British Columbia Interior.*

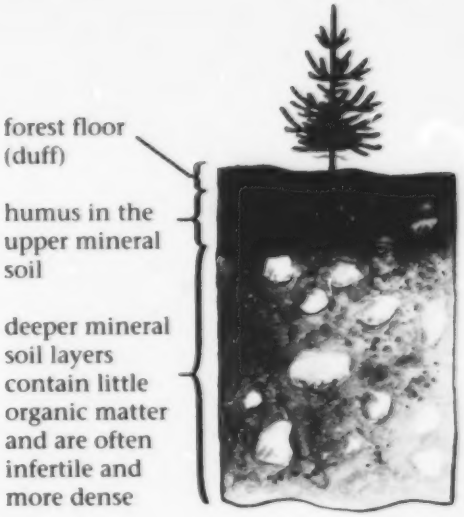
SITE PREPARATION METHODS

What makes a soil fertile?

Two of the most important factors are:

Organic matter

- contains the bulk of soil nutrients
- essential to biological activity in the soil
- helps retain moisture
- helps retain porous structure
- forest floor (duff) protects the underlying soil from structural damage and erosion


forest floor (duff)
humus in the upper mineral soil
deeper mineral soil layers contain little organic matter and are often infertile and more dense

Porous soil structure

- encourages root growth
- permits the free movement of air and moisture into the soil
- necessary for good soil drainage
- necessary for healthy biological activity

What is detrimental soil disturbance?

Two types of soil disturbance that can be very damaging to site productivity are:

Compaction

Compaction can be the result of machine traffic that is excessive or poorly timed, or the inappropriate choice of equipment. Soils are most prone to compaction when they are moist (wet). Soils with a high clay content are the most sensitive.

Well-structured, porous soil: good seedling growth

Dense, compacted soil, root penetration restricted, infiltration of air and water disrupted: poor seedling growth

Extensive soil displacement

Extensive soil displacement is the removal of forest floor and upper mineral soil layers beyond the seedling root system. Excessive soil displacement often results in the exposure of unfavourable material.

Nutrients removed, surface soil exposed to compaction, erosion and increased moisture loss.

SITE PREPARATION METHODS

No Site Preparation

Mechanical site preparation is suitable for most sites. The following are three sites that are not suited to site preparation:

Dry, nutrient poor sites

These sites often have coarse-textured soils and a shallow duff layer. An example is SBSmco2, Pine-Huckleberry-Cladonia

Naturally regenerated sites

Sites where the new stand is established through natural regeneration from the old stand.

Small wet pockets

Some sites contain small sections of wet ground that would require different scarification equipment than that used on the remainder of the area. These sections are often quite productive; therefore, one has to decide whether the total area of such sections is large enough to justify the use of a different machine, or should remain untreated. One alternative is to use a more expensive but versatile machine (such as an excavator) which can provide a variety of treatments.

Manual and Motor Manual Site Preparation

Manual and motor manual site preparation should be used on areas where slope, ground roughness, or site sensitivity prohibit the use of machinery.

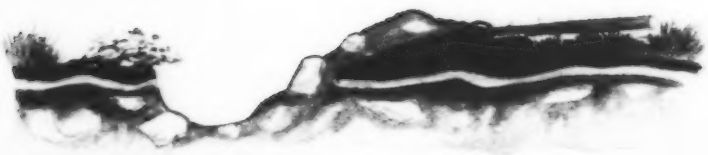
Manual site preparation is done with the planting shovel or by boot screefing.

Motor manual site preparation is done using modified brush saws or chain saws equipped with a site preparation blade. When performing motor manual site preparation, protective equipment, such as eye and ear protectors and leg guards, is required.

Mounding

Raised planting spots are usually good growing sites for seedlings, especially in cold, moist climates. Increased soil temperature, loose and oxygen-rich mineral soil, and good drainage promotes rapid root growth, seedling establishment, and early seedling performance. Mounds can control competing vegetation, retain nutrients of surface organic layers, increase light available to the crop seedlings and reduce the hazard of snow press and frost damage.

Mounds vary in size depending upon their composition and the objective of the mound treatment. On heavy, clay soils mounds require only 10–15 cm of mineral soil capping, while on wet organic soils mounds can be as large as required to elevate the seedling root system above restrictive high water tables. In most cases, mounds should not exceed 20–30 cm in total height after settling. Mounds must be wide enough to control competing vegetation. **In all cases, mounds should be formed with flat to concave tops and gently sloping sides, and should have good contact with the humus or soil layers below.** Concave tops are especially important on sites subject to seasonal drying as they help collect rainwater and prevent the mound from drying out. When forming mounds, care must be taken to avoid capping over slash or other debris, which would cause a barrier to root egress from the mound and increase the risk of the mound drying out.



Mounds may be composed of one of the following combinations:

- Mineral soil capping on inverted humus.
- Mineral soil capping on undisturbed duff.
- Mineral soil on mineral soil.
- Mixed surface organic matter and mineral soil.
- Well decomposed organic matter (peat soils) on organic matter.

Deep planting almost always applies when planting on mounds. Deep planting implies that the seedling is planted with the root collar buried at least 5 cm in mineral soil or humus. Inappropriate mounding or improper (shallow) planting can make the crop seedling vulnerable to drought and increase the risk of frost heaving. Deep planting also protects roots from being exposed due to weathering of the mound surface subsequent to planting.

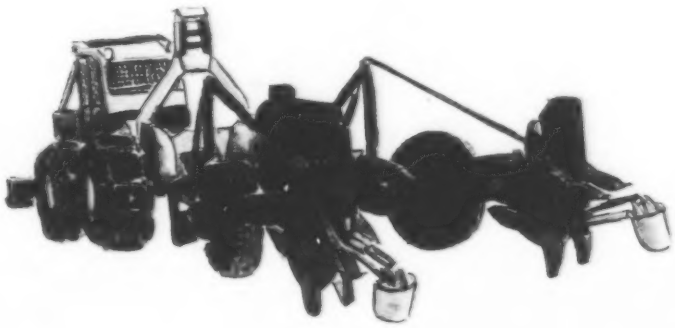
Mounding Equipment

To obtain good results, the choice of equipment used must match the operating conditions of the site and the type and size of mound to be created.

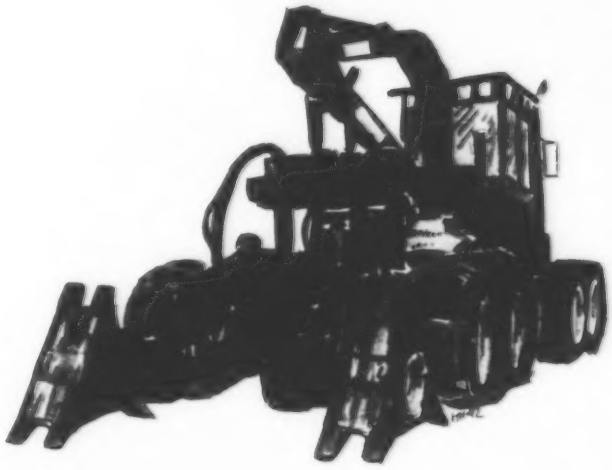
Pulled or Skidder Mounted Mounders

These are recommended on most sites with good trafficability and gentle slopes, however, they should not be used where any of the following conditions are present:

- Sites with heavy slash loading.
- Sites with a thick humus layer.
- Extremely wet sites.
- Sites with slopes greater than 20%.



Bräcke Mounder



Donaren 870 Mounder

Crawler Mounted Mounders

These units have the ability to work on a wider range of sites and on slopes up to 25-30%. The added power of a crawler, combined with a slash parting V-plow or rake, can successfully mound on sites with moderate to heavy slash loadings.

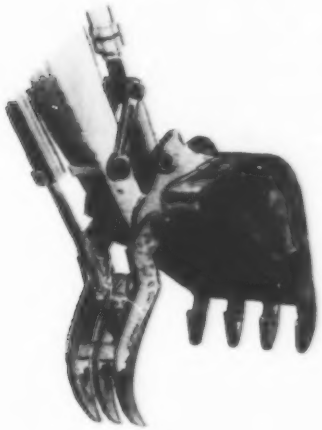
The B.C. Forest Service/Rivtow Mounder

Mounding Equipment

Excavator Mounding Attachments

Excavators are the most versatile, but costly, type of mounding equipment. They are recommended for all sites, but are especially cost competitive on sites with the following conditions:

- Sites with heavy slash loading.
- Sites with high stumps and many obstacles.
- Sites with a thick humus layer.
- Sites with a slope > 25%.
- Brushy sites.
- Wet sites.
- Sites where a variety of mound sizes and types are required.



Standard bucket with extended teeth and live thumb

Mounding rake

Öje Mounder

On extremely wet sites, mounding can be combined with ditching. However, ditching must be approached with caution, and carefully planned to avoid mineral soil erosion and stream sedimentation.

SITE PREPARATION METHODS

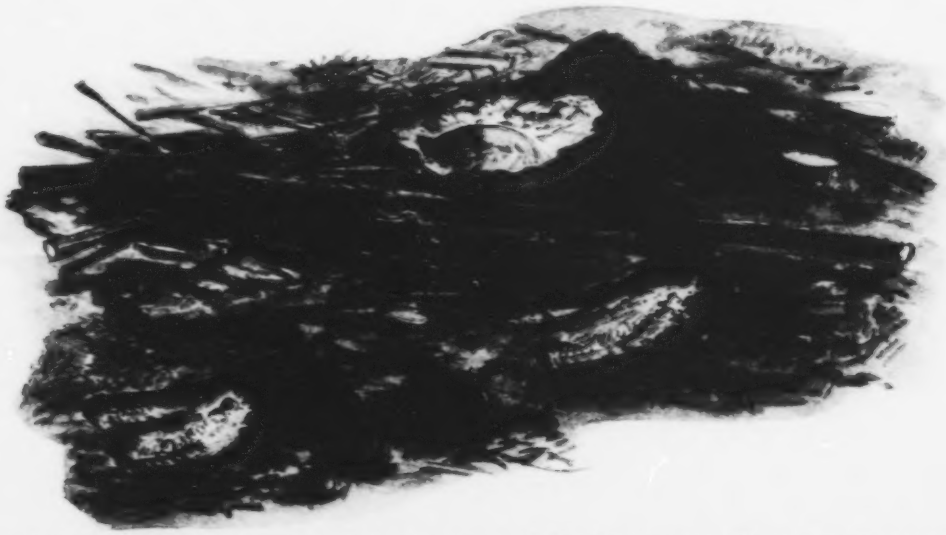
Scalping

During scalping, patches of mineral soil are exposed in a systematic pattern. Scalps should only be deep enough to remove unfavourable litter and duff layers, and expose well-decomposed organic or favourable mineral soil horizons. **Care must be taken to avoid scalping too deep or too wide,** especially on nutrient poor sites with a thin humus layer. Removing nutrients beyond seedling roots or exposing unfavourable soil substrates can lead to poor seedling performance. However, scalps must be large enough to reduce the influence of competing vegetation.

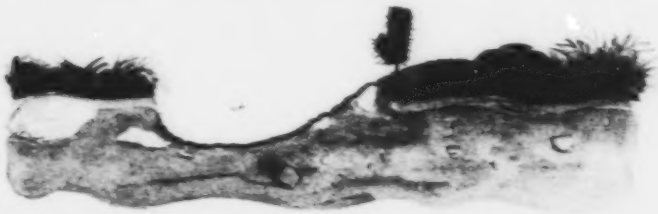
Scalping is recommended for sites with the following conditions:

- Dry sites.
- Sites with a thin humus layer.
- Sites subject to grazing (rangeland or wildlife).
- Sloped sites where erosion due to water channelling is a concern.
- Sites where continuous trenches would encourage the spread of unwanted vegetation.

Scalping should not be done on wet sites, where planting in scalped spots can place seedling roots in saturated soil. Scalping on fine-textured soils places seedlings at risk for frost heaving..



Depending upon the equipment used, scalping can produce a range of planting spots. Often a small mound of inverted humus, or sod, with some mineral soil is formed. On most sites, seedlings should be planted on the shoulder of the exposed mineral soil, adjacent to the inverted humus. On dry sites the seedling may be planted in the bottom of the scalp. **Scalping should not be done on sites prone to frost heaving.** Rather, on these sites seedlings need to be planted in the inverted humus with sufficient mound capping.



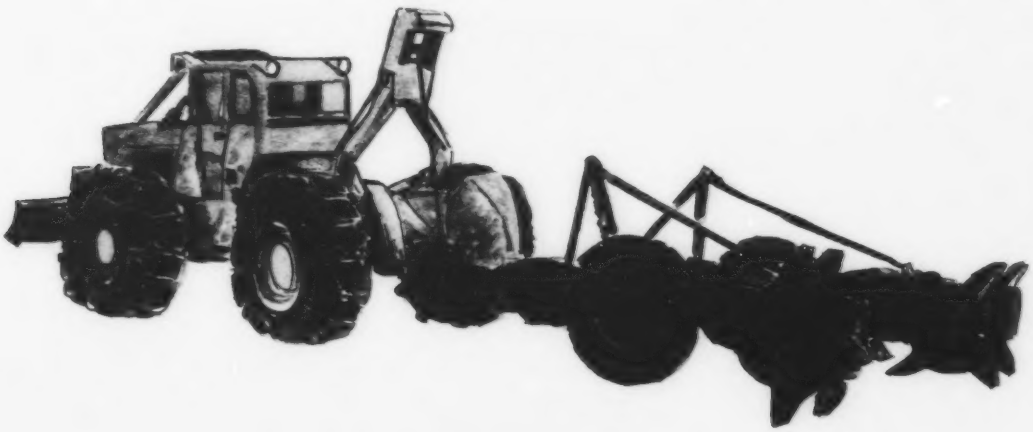
Profile produced by a Bräcke

Profile produced by a Leno

Scalping Equipment

Pulled or Skidder Mounted Implements

These are recommended on mosts sites with good trafficability, gentle slopes, and moderate humus depths. Skidder mounted implements are characterized by high productivity and low treatment costs.



Bräcke two-row scarifier

Leno scarifier

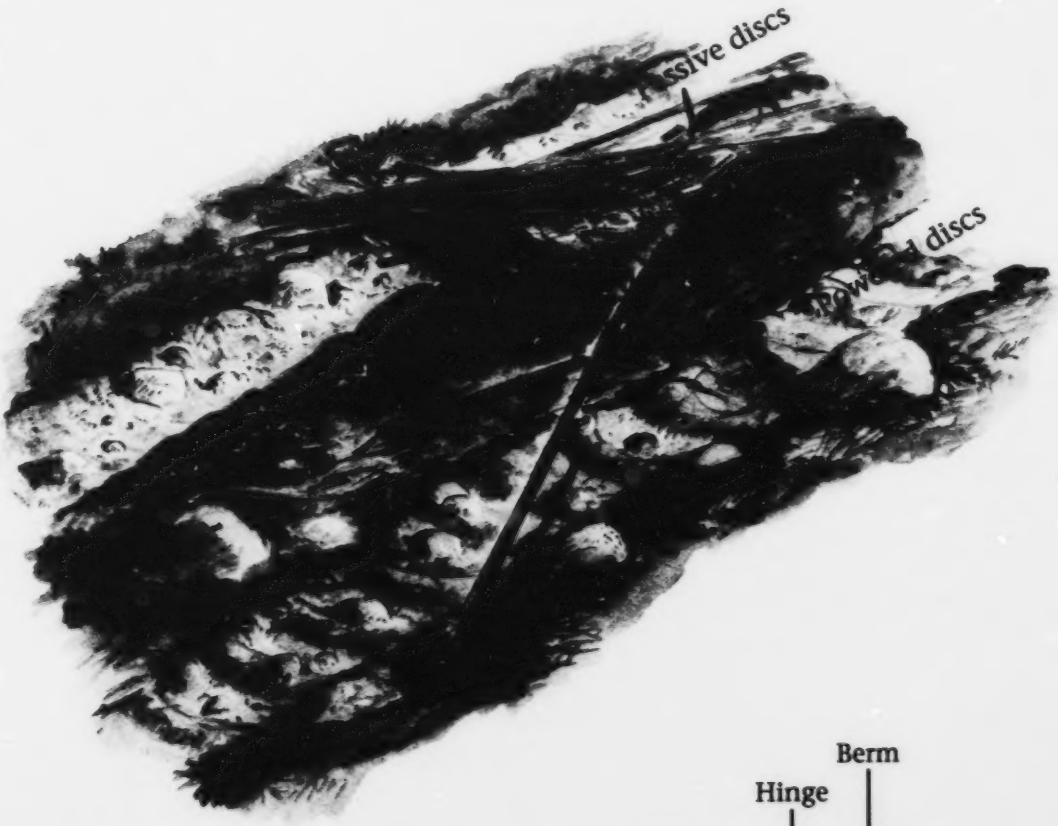
Excavator Attachments

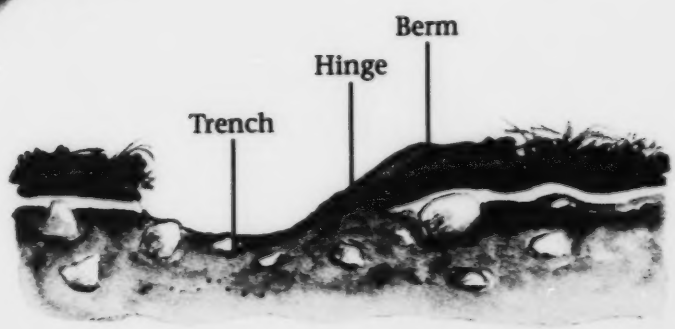
Standard buckets with teeth, or rakes, are all that is required for scalping. Excavators have generally low productivity and high treatment costs, and are used for scalping only on sites with steep slopes, heavy slash or high stumps, or where a variety of site preparation treatments is required.

Disc Trenching

The results of disc trenching vary, depending upon site factors, the type of disc trencher and what machine settings are used.

Disc trenchers are recommended for a wide range of sites, for natural regeneration or planting. They should not, however, be used on wet or steep sites. On rangeland (domestic or wildlife), or sloped sites where erosion from water channelling is a concern, disc trenching should only be performed intermittently.





Disc trenching can produce 3 distinct planting positions:

- Trench position for dry sites.
- Hinge position for medium sites.
- Berm position for moist sites.

The trench profile can be adjusted by changing the disc angle, down-pressure, and travel speed. A disc angle more perpendicular to the direction of travel produces a wider, flatter trench, while a disc angle more parallel to the direction of travel produces a deeper, narrower trench. By increasing the down-pressure and decreasing the travel speed, a deeper trench and a well formed berm are produced.

Disc Trenching Equipment

Disc Trenchers

Disc trenchers can be grouped into three distinct categories: passive trenchers, trenchers with hydraulic down-pressure but passive discs, and trenchers with hydraulic down-pressure and powered-discs. The most common trenchers used in Western Canada have hydraulic downpressure and powered-discs. They are recommended for sites with heavy slash or a relatively deep humus layer, or any other application requiring good disc penetration or berm formation. For proper operation, disc trenchers should never be operated at travel speeds greater than 5 km/h (3 mph). On sites with heavy slash, a v-rake can be used to align the slash immediately prior to trenching.

Some powered-disc trenchers have the ability to trench intermittently. These trenchers are recommended for trenching slopes that are too steep to treat by contouring.

Prime Movers

Disc trenchers have been mounted on a variety of prime movers. When selecting the prime mover the following considerations are important:

- Match the prime mover to the site conditions (i.e., slopes, slash loading, trafficability).
- Meet the hydraulic requirements of the disc trencher.
- Match the transmission to high drawbar pull requirements at slow travel speeds (especially if a slash parting device is to be used as well).

TTS powered-disc trencher mounted on a crawler

Mixing

Appropriately executed mixing can control competing vegetation, increase soil temperature and aeration, decrease soil bulk density, improve soil water relations, and retain nutrients stored in surface organic layers immediately available to crop seedlings. However, inadequate mixing can stimulate competing vegetation and introduce air pockets.

Coarse Mixing

Coarse mixing is accomplished using large discing implements that heap clods of surface organic and mineral soil layers into a bed. Coarse mixing provides little control of competing vegetation, but is beneficial where low soil temperatures and/or high soil water tables inhibit seedling growth.

On sites with high competing vegetation potential, coarse mixing must be followed by planned brushing treatments.

Eden Bedding Plow

Mixing

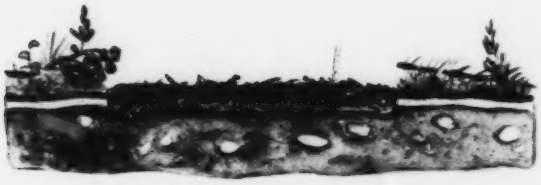
Fine Mixing

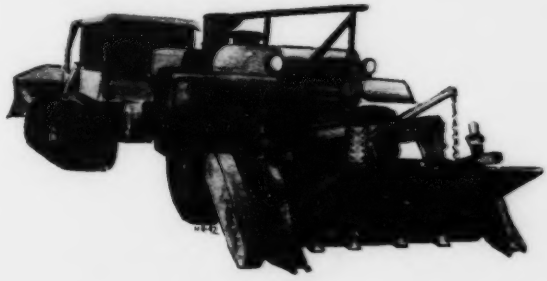
Fine mixing is used on sites with high competing vegetation potential, where high rotovation speed is required to chop propagating plant parts small enough to control resprouting. Fine mixing requires slow travel speeds to allow sufficient time to chop up the soil and vegetation.

Fine mixing is suitable on fine-textured soils, with few cobbles or boulders. It is unsuitable on sites with the following conditions:

- Stony or bouldery soils.
- Coarse-textured soils with a thin humus layer.
- Wet sites (unless they can be subsequently bedded or mounded).

Fine mixing will result in shrubby vegetation complexes, such as willow or aspen, being replaced by herbaceous vegetation and grass. This shift in vegetation complex may not be desirable on certain ecosystems.



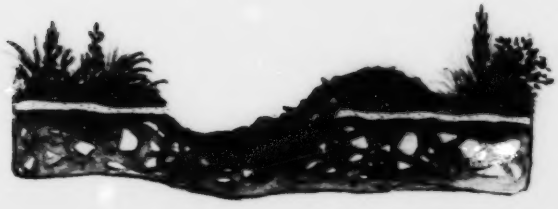


The Madge Rotoclear

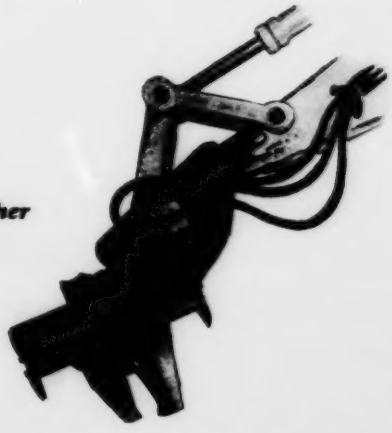
Spot Mixing

Spot mixing is prescribed for sites where mixing is biologically appropriate, but where slash, stumps or other obstacles prohibit use of strip mixing implements. Spot mixing is also used on sites where minimal soil disturbance is required.

Spot mixing implements are usually mounted on excavators, as excavators are able to work on a wide range of sites.



V-H Mulcher



Ripping - Plowing

Ripper plows are essentially modified standard ripper teeth, on the back of a crawler tractor, and were specifically designed for treating wet ground when it is frozen. The most common plow design is a double mouldboard type with replaceable cutting edges, which attaches to the ripper shank of the crawler tractor. The ripper tooth digs into the soil, while the plow attachment displaces soil on either side.

Wet sites — prepared in the winter when frozen

The ripper plow is recommended for the following conditions:

- Wet spruce sites with thick duff layers.
- Muskeg sites (with deep organic soils) that must be planted and cannot be burned.

The ripper plow is not suited for the following conditions:

- Broken or rugged terrain.
- Slopes >25%.
- Dry sites with thin humus layers.
- Unfrozen ground.

Seedlings are planted on acceptable, raised microsites. However, a clearly defined berm is not always produced (depending upon snow conditions during treatment). Plowing does not control competing vegetation such as grass. The deep furrow associated with this treatment can cause asymmetric root systems, as roots will not cross the dense, often wet, fine-textured soils at the bottom of the furrow.

Dry sites

Smaller, two-row ripper plows were designed to create planting furrows on dry sites in the Southern Interior of the Province. Seedlings are planted in the bottom of the furrow and benefit from some degree of frost protection due to reradiation of heat from the soil at nighttime, less winter damage and increased moisture availability. However, seedlings are prone to trampling damage as cattle will travel down plowed furrows. Plowing too deep (i.e., down to unfavourable substrates) will result in poor seedling performance.

Sanders-Araki Plow for use on dry interior sites.

CHOOSING THE SITE PREPARATION METHOD

Planning

The site preparation method should be considered as part of the logging planning.

Matching the Method to the Site

Specific prescriptions similar to the general example given below should be developed for your operating areas.

Method		Coarse to medium-textured soils				Fine-textured soils			
	Slash/Obstacles:	Heavy		Light		Heavy		Light	
	Humus Layer:	Thick	Thin	Thick	Thin	Thick	Thin	Thick	Thin
Spot scalping	Dry site		■		■				
	Medium site	■	■	■	■				
	Wet site	■		■		■		■	
Disc trenching	Dry site						■		■
	Medium site		■	■	■		■	■	■
	Wet site	■				■			
Mounding	Dry site		■		■		■		■
	Medium site								
	Wet site	■		■		■		■	
Coarse mixing*	Dry site		■		■		■		■
	Medium site	■	■		■	■	■		■
	Wet site	■		■		■		■	
Fine mixing*	Dry site		■		■		■		
	Medium site	■	■		■	■	■		■
	Wet site	■		■		■		■	

■ Recommended method □ Acceptable method ■ Unsuitable method □ Not applicable

*** Strip mixing equipment is limited by heavy slash. Mixing with an excavator is acceptable on these heavy slash sites.**

On sites subject to frost heaving, always plant on turned humus soil.

Plantable Spots

When determining the number of spots to be created for an area, the appropriate regional stocking standards should be considered. Regional stocking standards are based on correlated ecosystem descriptions, knowledge of moisture and nutrient regimes, and site capabilities. Target and minimum stocking standards are reduced for extremely dry and wet ecosystems to reflect site specific carrying capacities. An example of free growing stocking standard guidelines is given below.

ESSFd (ESSFxc)–Kamloops Forest Region

Ecosystem Association /Site Series		Free Growing Stocking Standards (well spaced/ha)	
Number	Name	Target	Minimum
01	Bl-Grouseberry-Valerian	1200	700
02	Pl-Juniper-Lupine	600	400
05	Bl-Grouseberry-Cladonia	1000	500
08	Bl-Horsetail-Glowmoss	1000	500
09	Bl-Bluejoint-Sedge	no treatment	

Stocking standards do not establish planting levels directly; rather, they set the standard for the number of well spaced trees required at free growing. A free growing plantation must be at least 5 years old. "Free growing trees" are healthy, undamaged, and free of above-ground competing vegetation. When determining the actual number of plantable spots required on a site, plantation mortality and "fill in" by naturals must be considered. Stocking standards may also be modified on a site specific basis to accommodate integrated resource management or other issues.

Once the required number of planting spots has been determined, the need for creating or improving microsites by site preparation must be established. Some sites have a sufficient number of acceptable planting spots available without site preparation, while other sites require site preparation to create the required number of acceptable planting spots.

Before site preparation begins, the acceptable planting spot or microsite to be created must be clearly defined. Contract spacing will be determined by the number of microsites that must be created.

Plantable Spots

Density (spots/hectare)	Contract Spacing (metres)
1200	3.1
1400	2.9
1600	2.7
1800	2.5

Contract spacing is the specified normal distance between prepared microsites. A minimum contract spacing (i.e., the minimum allowable distance between prepared spots) will also be specified. Minimum spacing must be consistent with the minimum spacing specified in the pre-harvest silvicultural prescription. Occasional reductions in spacing must be offset with increases elsewhere to maintain the correct density.

Plantable Spots

Row site preparation (e.g., disc trenching, Brücke patch)

Fixed settings on certain types of equipment or difficult site conditions may make uniform spacing impossible. Under such conditions, the total number of prepared planting spots may still be created if "in-row spacing" is reduced to compensate for wider spacing between rows. However, "in-row spacing" must never be closer than the minimum contract spacing and the distance between trenches should not be greater than twice the row spacing.

The number of rows per 100 metres depends on the distance between acceptable planting spots within the row.

"In-row Contract Spacing" (metres)	Number of Planting Spots/ha				
	1000	1200	1400	1600	1800
	Number of rows per 100 metres				
1.9	19	23	27	30	34
2.1	21	25	29	34	38
2.5	25	30	35	40	—
2.7	27	33	38	—	—
3.0	30	36	—	—	—

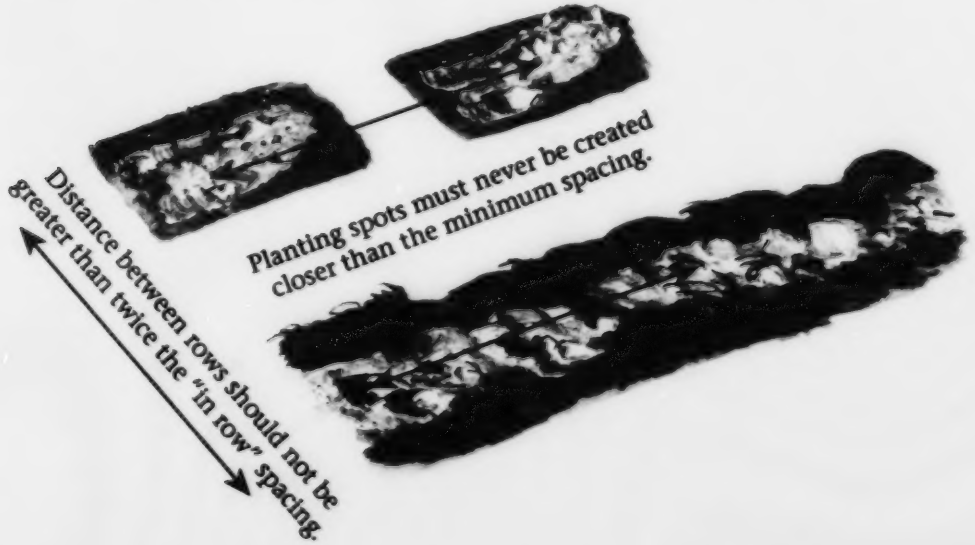
Disc trenching

With disc trenching, the desired contract spacing within a row can generally be attained. The number of rows required to attain the appropriate density can then be read in the table.

Spot scarification and mounding

The following is an example of how the table is used when setting the adjustments of the spot scarifier mounder.

- The desired number of planting spots is 1400/ ha.
- The scarifier is set at 2.1 m.
- The table reads 29 rows per 100 m.
- After a few passes, the number of acceptable planting spots is recorded at 80%.
- The correct number of rows per 100 m is then 29 divided by 0.80 = 36 rows per 100 m.


Planting spots must never be created closer than the minimum spacing.
Distance between rows should not be greater than twice the "in row" spacing.

MATCHING THE SITE PREPARATION METHOD TO THE SITE

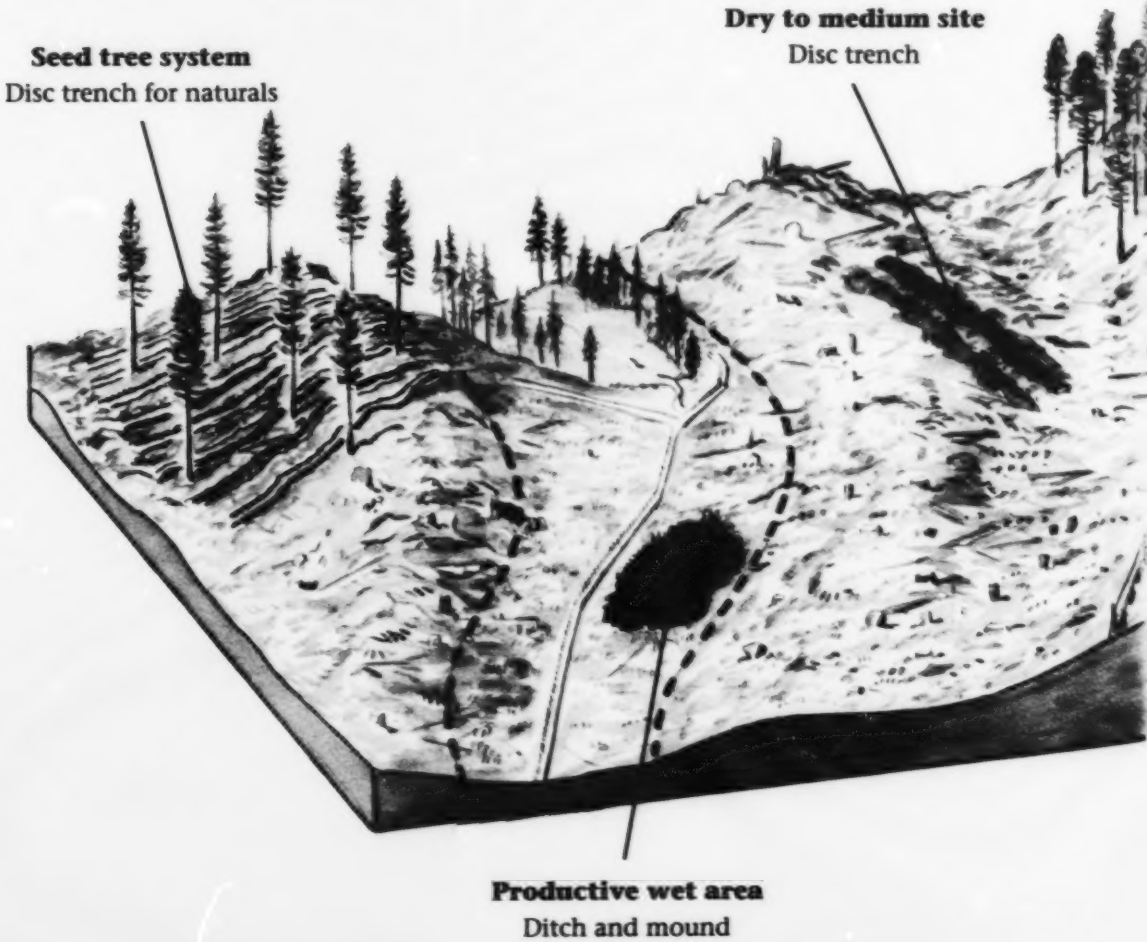
Over a small geographic area (even within one cutover) conditions may vary (e.g., moisture, soil type, slash loading, humus depth, and other factors). To obtain the best result, the site preparation method must be matched to these conditions.

Practical Application

First, the equipment operator must be aware of the opportunities of using a site preparation machine in more than one way. For example, an excavator can scalp as well as mound.

It is essential that the operator knows the objectives of the different site preparation methods to be used, and has been trained to recognize where to apply the different methods.

In some cases the area of differing conditions may be large enough to consider using an additional machine.

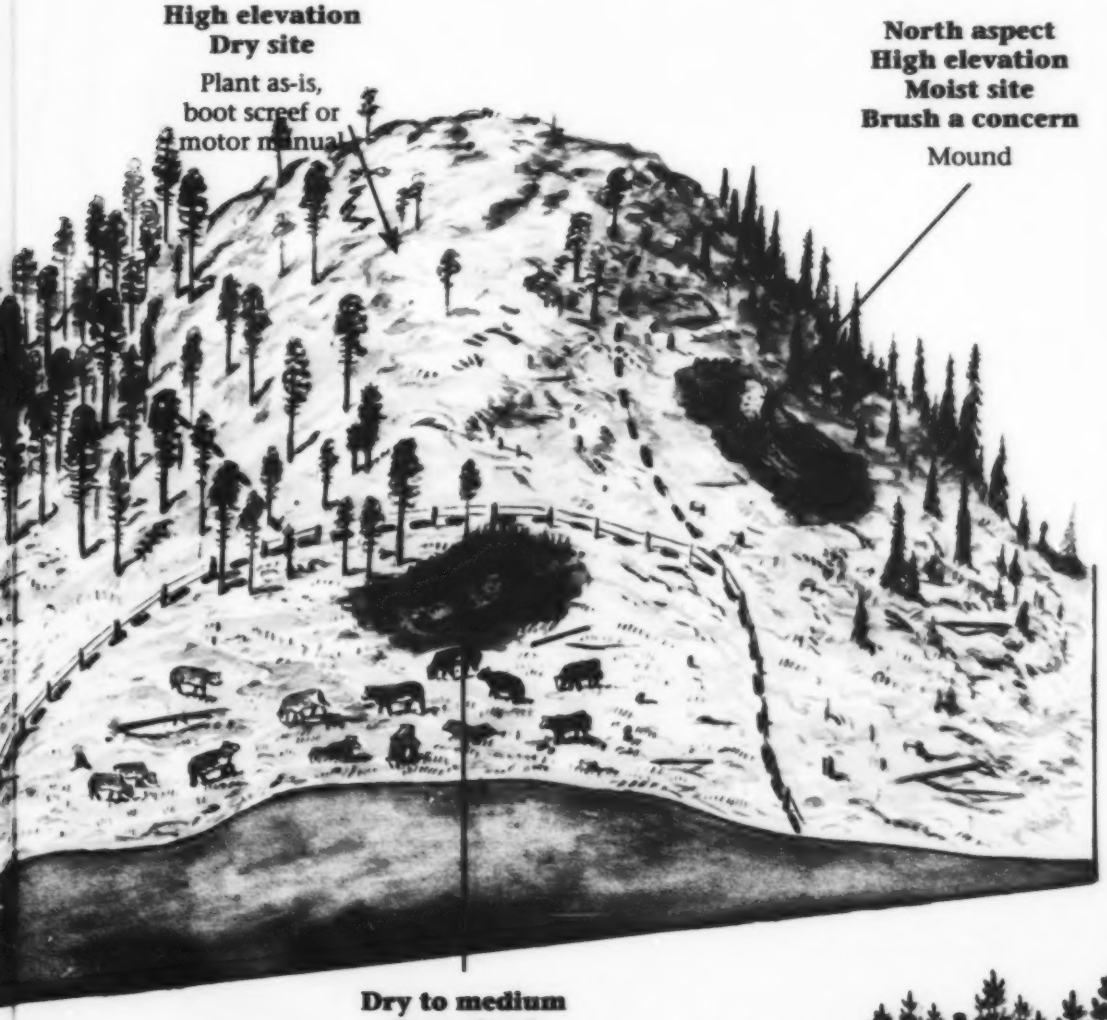


MATCHING THE SITE PREPARATION METHOD TO THE SITE

Cost Considerations

The cost of a more expensive site preparation method, or of using several methods on the same cutover, must be weighed against the risk that the planting may fail on parts of the cutover, resulting in expensive replanting. It is cost effective to spend more to avoid failures. However, to switch from an acceptable to a better site preparation method may not be cost effective.

Site prepare only those parts of a cutover where the machine being used will give an acceptable result.



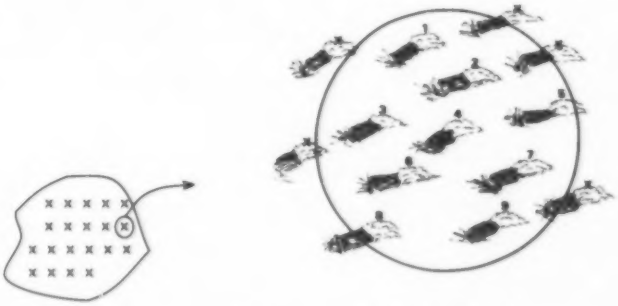
Areas with acceptable natural regeneration should never be site prepared unless specified by the project supervisor.

POST TREATMENT FOLLOW UP

Follow up is the responsibility of both the operator and area supervisor. In order for the operator and his supervisor to agree on the quality standard of the site preparation, there must be good communication between the two. This requires both parties to put in sample plots. **The first check should be done after about five minutes of work on a cutover.** Thereafter, the quality of work should be spot sampled as required throughout the day. New checks should always be carried out when the conditions are changing on the cutover.

Sampling Method

In British Columbia, where mechanical site preparation is used to create microsites for planting, a 50 m^2 (1/200 ha–3.99 m radius) plot is usually used to assess treatment quality. Where planting densities are to be below 900 trees/ha, plots of 100 m^2 (1/100 ha–5.64 m radius) are allowed. For samples to be statistically accurate, a sample of one 50 m^2 plot/ha is usually sufficient for larger units. The number of plots on any one payment unit must never be less than 20. **The circular plot is particularly applicable for work that tends to be more random;** for example, work with an excavator. Using the circular plot, the operator lays out a random circular sample plot with a 3.99 m radius and records the number of acceptable planting spots within the circle. The average number of planting spots from several plots multiplied by 200 gives the average number per hectare. (Where the larger 5.64 m radius plot is used, the average number of planting spots from several plots should be multiplied by 100.)



1/100 ha – 5.64 m radius

When assessing acceptable planting spots only count the specific microsite that will be planted. For example, if a seedling is to be planted on top of a mound do not count a microsite where the patch falls within the circle but the mound is outside the circle. If the average number of acceptable planting spots (microsites) is less than called for in the contract, the operator should consider tighter spacing. If tighter spacing is not possible, the operator should discuss the problem with his supervisor.

Where the site preparation method is less random in nature (for example, relatively uniform rows) a quick check may be used by the operator to ensure that contract spacing is being maintained.

Spot Scarification and Mounding

Record the number of rows per 100 metres. Next, select one row by random; for example, the last one on the 100 metre stretch. On this row, check the number of spot- making attempts for 30 metres and the number of attempts that resulted in acceptable planting spots.

Disc Trenching and Plowing

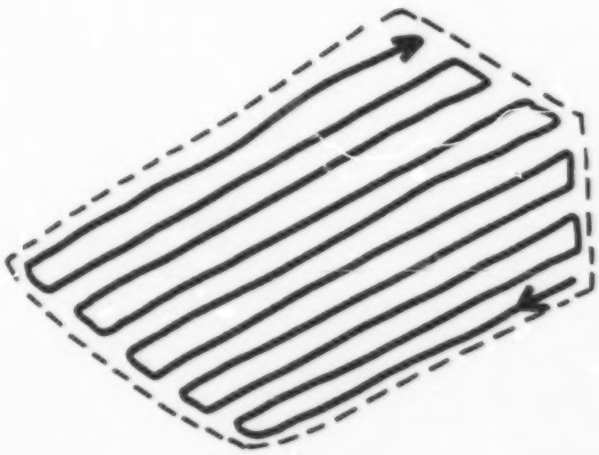
Record the number of trenches per 100 metres. Next, check the number of acceptable planting spots along 30 metres of trench. The standard contract spacing should be used to assess plantable spots. A spot is not acceptable if it is closer than the minimum contract spacing.

OPERATIONAL CONSIDERATIONS

Treatment Patterns

Concentric pattern

This pattern is used when you want to minimize time spent turning, or when turning is difficult; for example, drag scarification. The operator begins along the outer edge of the cutover and continues to go around and around until the whole area is treated.



Back-and-forth pattern

Use this pattern when other considerations, such as planter access or aspect, take priority over productivity. The operator begins at one end of the cutover and drives back and forth in parallel runs, usually perpendicular to the road. The runs should be longer than 150 m to keep the turning time in proportion with the total time spent working.

Fire Safety

During dry periods, sparks can fly from the prime mover, or implement, and ignite ground vegetation or logging debris. Site preparation operations should be equipped with the following safety equipment:

- Two-way radio or mobile telephone.
- Two hand-held fire extinguishers (chemical).
- Light water pump extinguisher.
- Axe and spade.
- Other firefighting equipment specified by the B.C. Ministry of Forests.

Welding, cutting, and metal grinding should not be carried out in the cutover.

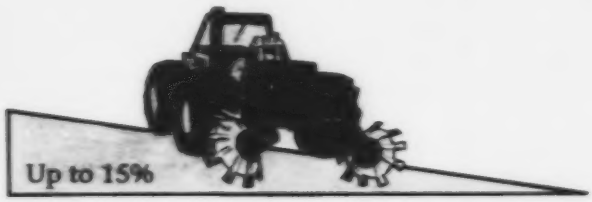
During periods of high fire hazard, personnel with firefighting equipment should be posted to watch over the workplace after treatment has ended, or repair work completed.

Complete directions for firefighting must be supplied by the supervisory staff.

OPERATIONAL CONSIDERATIONS

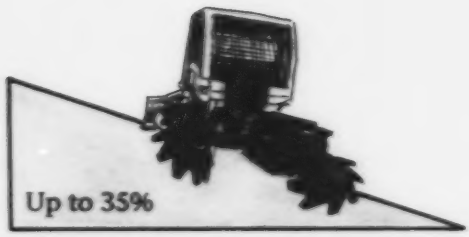
Operating in steep terrain

For safety reasons, equipment should not be operated on areas beyond the safe slope capacity of the prime mover. The maximum slope that can be safely traversed will decrease with increasing stump height, slash loading or ground roughness. Extra caution must be exercised on slopes, resulting in reduced productivity. Ground workers must not work below equipment on slopes.



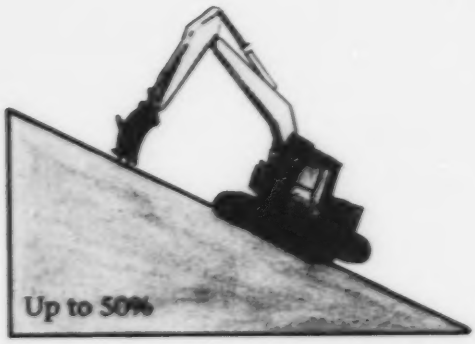
Wheeled skidders

Travelling parallel to the contour on slopes greater than 15 % should not be attempted. Slopes up to 25 % may be treated downhill, but only with spot scarification or intermittent disc trenching. Six- or eight-wheel forwarders may treat slightly steeper slopes. Wide tires provide better stability on side slopes but are prone to slipping on wet slash.



Crawler tractors

Travelling parallel to the contour should only be attempted on slopes up to 35%. This can vary depending upon equipment size and type. Soft-track FMC's may treat slopes up to 40%. Slopes up to 45 % may be treated downhill, but again only with spot scarification or intermittent disc trenching.



Excavators

Excavators can treat slopes up to 50%. Short slopes > 50% may also be treated depending upon boom reach or skid trail access.

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